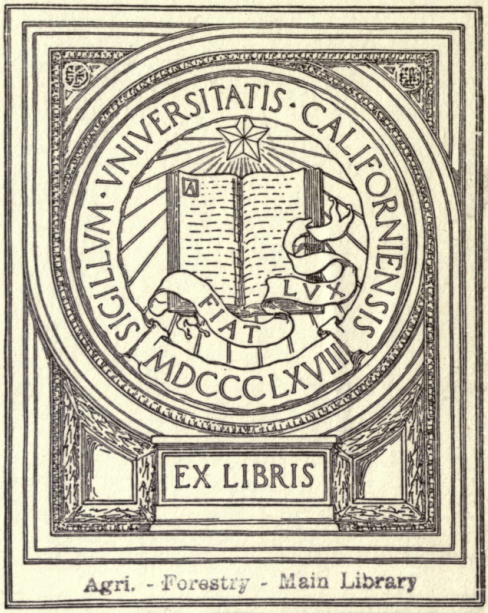

FEDERATED MALAY STATES.

REPORT

ON THE

RESULTS OF MECHANICAL TESTS CARRIED OUT ON SOME MALAYAN TIMBERS

BY

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The tests referred to in this report are preliminary to a more extensive series of tests which are to be carried out as soon as the necessary machinery can be obtained. It is realized that these tests do not cover the whole ground, but as some considerable time must elapse before the complete tests can be made, it has been decided to publish the results obtained to date in the belief that they may be of practical use to engineers.

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REPORT ON THE RESULTS OF MECHANICAL TESTS CARRIED OUT ON SOME MALAYAN TIMBERS.

No reliable data has been published of the mechanical properties of the Malayan timbers and the lack of such has been frequently commented upon. It is with a view to supplying some approximate figures relating to the properties of the local timbers that these notes are put together. Originally the tests were made on a few selected timbers to determine their suitability or otherwise for use in aeroplane construction and it was intended that the tests should be of a preliminary nature only, and that specimens of timbers thought to be suitable would be sent to England to have tests of a more detailed nature carried out upon them. It was soon found that the result of the tests might be of more general use than for the specialized purpose originally intended, and the scope of the investigation was therefore enlarged and the figures tabulated below are taken from tests made on 689 specimens. As noted above the tests can only be accepted as of a preliminary nature for although some considerable care has been taken to make the tests as accurate as possible yet the lack of a suitable machine and suitable measuring apparatus has been severely felt. A further difficulty in obtaining suitable seasoned material has necessitated a number of unseasoned specimens being used in the test, rendering strict comparison between the various tests difficult. On the other hand the tests may be said to have been made on material similar to that used in good general construction, and may therefore be accepted as a guide in future design.

2. The tests were carried out on specimens in cross bending and the results are therefore most applicable to beams used to resist bending moments. No tests were carried out under compression, direct shear or impact nor was any attempt made to compare the hardness of the various timbers as the machine available was not adaptable for such tests. For purposes of comparison it should be noted that the tests were carried out on specimens approximately 2″ × 1″ in cross section and the results reduced to the recognized square inch basis. This is mentioned as it has been found that results obtained from small specimens are in general higher than those obtained from specimens of a larger cross section. All tests were carried out on an "Avery" 2-Ton Machine using the "three point suspension" method; the specimens being loaded centrally and supported on rigid supports 18″ on either side of the centre. In general the loads were applied by hand in ½ cwts. increments at the rate of 1 ton per hour. The deflections of the beam were measured after each increment of load and were determined by the movement of the timber at the point of load. No allowance has been made for local crushing which was small in most cases. The apparatus to hand did not permit of a more accurate determination of the deflection. The curve connecting load and deflection for each specimen was plotted and the yield

point maximum load, etc., determined from the curve, the constants given for each timber being reduced to the square inch basis of comparison.

3. The weight per unit volume of timber was calculated from measurements and weighings of the whole test piece (some 80 cubic inches in volume) made at the time of test, and reducing the weight per unit volume so obtained, in the ratio of the weight of a small piece ($2\frac{1}{2}$" long cut at a standard distance of 6" to $8\frac{1}{2}$" from one end of each specimen) weighed immediately after being cut to the weight of same piece after having been oven dried. Thus the weight per cubic foot tabulated is the weight in lbs. of a specimen of the wood *oven dry* which was *one cubic foot in volume at the time of test.* Owing to the shrinkage which takes place in wood when it is dried the figure so obtained is not the true weight per unit volume of a piece of oven dry wood. This is, however, the method generally adopted of determining the weight of timber.

The specific gravity can be obtained by dividing each result by $62\frac{1}{4}$ (approx.). The air dry weight of any of the timbers can be obtained by adding 12 per cent. to 15 per cent. to the oven dry weight.

4. The results of the tests have been grouped together in batches, each batch being composed of several specimens obtained from one tree and the average, maximum and minimum figures (excluding results obtained from damaged specimens) for oven-dry weight elastic limit, modulus of elasticity and modulus of rupture have been tabulated. By comparing the average with the maximum and minimum figures given an idea of the reliability or otherwise of the timber can be obtained. The strength of any wood (the modulus of ruptnre) appears to bear a distinct relation to its weight. This relationship is fairly well expressed by the linear equation:

$$R = .154\ w$$

"R" being equal to the modulus of rupture in tons per square inch and "w" being the oven dry weight of one cubic foot of the timber. An equation which is more cumbersome to use, but which appears to express the relationship rather more accurately is of the form

$$R = a\ w^{n}$$

"a" and "n" being constants. Too few tests have as yet been made to definitely determine the best values for "a" and "n" but it appears that the equation

$$R = \frac{w^{1.25}}{16.8}$$

satisfied the plotted values fairly well.

5. Several notes are appended regarding the general behaviour of the timbers tested and it is hoped that these may be of value. The notes are not intended to be exhaustive but are results of observations made on the specimens when under test. It should be noted how in general the air-dried specimens are stronger than those which contain more moisture.

LIST OF WOODS USED IN MECHANICAL TESTS.

Batch No.	Common name.	Latin name.
1	Damar Minyak	Agathis alba
2	Seraya—No. 86	Shorea Curtisii
3	Seraya—No. 106	Shorea Curtisii
4	Nyatoh	Palaquium sp.
5	Bintangor	Calophyllum sp.
6	Bintangor	Calophyllum sp.
7	Nyatoh	Palaquium sp.
8	Bungor	Lagerstroemia sp.
9	Merawan	Hopea sp.
10	Kungkur	Albizzia sp.
11	Dedali	Strombosia javanica
12	Dedali	Strombosia javanica
13	Sanai or Mersawa...	Anisoptera sp.
14	Medang Tandok	Litsea ? sp.
15	Medang	Litsea sp.
16	Chengal or Penak...	Balanocarpus sp.
17	Chengal or Penak...	Balanocarpus maximus
18	Keranji	Dialium platysepalum
19	Merawan	Hopea sp.
20	Belian	Payena utilis
21	Betis	Payena utilis
22	Punggai	Coelostegia Griffithii
23	Ru	Casuarina equisetifolia
24	Perepat	Sonneratia sp.
25	Tempinis	Sloetia sideroxylon
26	Pulut Pulut	Ficus sp.
27	Keladan	Dryobalanops sp.
28	Resak	Shorea barbata
29	Kapur	Dryobalanops aromatica
30	Perian	Artocarpus rigida
31	Tualang	Koompassia parvifolia
32	Rengas	Melanorrhoea ? sp.
33	Bakau Minyak	Rhizophora conjugata
34	Kapur	Dryobalanops aromatica
35	Keruing	Dipterocarpus sp.
36	Kulim	Scorodocarpus borneensis
37	Kungkur	Albizzia sp.
38	Muntelor	Parinarium sp.
39	Merawan	Hopea sp.
40	Keledang	Artocarpus lanceaefolia
41	Penaga or Lenggapus	Mesua ferrea
42	Meranti Kait Kait	Shorea sp.
43	Berangan	Castanopsis sp.
44	Jelutong	Dyera costulata
45	Jahor	Cassia siamea
46	Petaling Gajah or Kamap ...	?
47	Pagar Anak	Ixonanthes icosandra
48	Kelat	Eugenia Ridleyi
49	Seraya Batu	Shorea sp.
50	Petaling Gajah or Kamap ...	?
51	Merbau	Intsia (Afzelia) sp.
52	Tempinis	Sloetia sideroxylon
53	Damar Hitam	Balanocarpus penangianus
54	Damar Laut Daun Kechil ...	Shorea sp.
55	Damar Laut Daun Besar... ...	Shorea sp.

Botanical name.	Material batch number.	Name of timber.	Per cent. moisture at time of test.	Dry weight in lbs. per cubic foot.			Elastic limit in lbs. per square inch.			Modulus of elasticity in 10C lbs. per square inch.			Modulus of rupture in tons per square inch.			Number of specimens in batch.	Remarks, *See* page 9,
				Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Agathis alba ...	1	Damar Minyak ...	18	31	32	29	6,600	7,250	6,200	1.91	2.04	1.81	5.15	5.47	4.92	6	(*a*)
Shorea Curtisii Dyer	2	Seriah No. 86 ...	19	29	30	27	5,170	8,150	4,680	1.97	2.02	1.88	5.08	5.40	4.73	6	(*b*)
,, ,, ...	3	,, 106 ...	19	35	36	34	5,750	6,340	4,700	1.54	1.70	1.41	4.55	4.97	4.04	3	
Palaquium sp. ...	4	Nyatoh	17	42	44	38	8,000	9,550	6,500	2.45	2.54	2.31	6.41	6.95	5.74	6	
Calophyllum sp. ...	5	Bintangor ...	16	31	34	27	5,730	7,950	4,530	1.90	2.16	1.61	5.01	5.50	4.73	6	(*b*), (*p*), (*r*)
,, ...	6	,, ...	20	35	37	33	8,020	9,700	7,100	2.34	2.52	1.84	6.39	7.03	4.92	6	(*p*), (*r*)
Palaquium sp. ...	7	Nyatoh	16.5	29	29	29	6,270	6,950	5,900	1.63	1.70	1.52	4.58	5.18	4.39	6	
Lagerstroemia sp.	8	Bungor	19	32	33	26	6,710	7,160	6,340	1.61	1.71	1.46	5.30	5.81	5.00	6	(*p*)
Hopea sp. (Merawan)	9	Pengawan Penak	15	34	38	33	7,480	10,700	6,150	1.87	2.04	1.71	5.66	5.94	4.05	6	(*b*), (*e*)
Albizzia (?) sp. ...	10	Kungkor	15	26	30	23	7,400	8,100	6,850	1.55	1.62	1.45	4.63	4.92	4.48	6	(*e*), (*j*)
Strombosia javanica	11	Dedali	20	34	35	33	5,300	5,650	4,980	1.56	1.68	1.45	3.77	3.85	2.76	7	
,, ,, ...	12	,, ...	40	37	39	32.5	5,600	6,500	4,060	1.90	2.18	1.47	4.97	5.8	4.1	17	(*b*), (*f*)
Anisoptera sp. ...	13	Sanai	19	30.5	32	29	4,900	5,750	3,860	1.44	1.55	1.30	4.10	4.2	3.8	7	
Litsea ?	14	Medang Tandok ...	16	45	46.5	44	8,000	8,500	7,550	2.31	2.41	2.08	7.0	7.3	6.2	7	(*p*)
,, ...	15	Medang	20	37.5	40	34	4,700	6,350	3,680	2.00	2.35	1.42	4.1	5.3	2.1	12	(*b*), (*c*), (*d*), (*g*), (*j*)
Balanocarpus sp....	16	Chengai	17	38	40	37	9,600	10,350	7,900	2.07	2.30	1.88	6.3	6.75	4.6	6	(*p*)
,, maximus	17	,, ...	17	49	50	45.5	11,100	12,800	9,150	2.45	2.76	2.04	7.3	8.0	6.8	12	(*p*)
Dialium platysepalum	18	Kranji	23	49	50	46	11,000	13,800	8,800	2.97	3.17	2.56	8.3	9.35	7.4	18	(*b*), (*h*), (*p*)
Hopea sp.	19	Merawan	22	36.5	39	35	8,360	10,200	6,970	2.84	2.95	2.68	6.9	7.2	4.3	7	(*p*)
Payena utilis ...	20	Belian	17	64	66	61	14,350	14,900	13,600	3.43	3.54	3.32	10.9	11.8	9.3	6	(*p*)
,, ...	21	Betis	17	61	63	60	14,000	14,700	13,500	3.61	3.74	3.54	10.45	11.2	9.05	9	(*p*)
Coelostegia Griffithii	22	Punggai	19	33.5	35	32	6,750	8,200	6,000	2.10	2.20	1.96	5.54	6.0	5.15	12	

Casuarina equisetifolia	23	Ru...	20	49	55	38	8,(00	10,100	2,300	2.26	2.68	1.49	7.0	8.2	1.7	12	(*b*), (*c*), (*d*), (*j*)
Sonneratia sp. ...	24	Perepat	25	41	45	37	6,500	7,550	6,050	1.91	1.99	1.82	5.9	6.55	5.4	9	(*e*)
Sloetia sideroxylon	25	Tempinis	14	56.5	58	55	11,900	15,200	10,000	2.95	3.15	2.72	9.2	11.0	7.8	6	(*p*)
Ficus sp.	26	Pulut Pulut ...	17	21	24.5	18.5	3,770	5,600	2,840	1.12	1.30	.92	3.3	4.1	2.7	9	(*b*)
Dryobalanops sp. ...	27	Keladan	21	37.5	40	36.5	5,600	6,050	4,900	1.99	2.22	1.79	5.48	5.85	5.2	9	(*p*)
Shorea barbata ...	28	Rasak	18	51	54	45	8,420	10,500	7,400	2.85	3.21	2.64	8.72	9.85	7.85	11	(*p*)
Dryobalanops aromatica	29	Kapur	18	40	42	38	6,700	7,650	5,700	2.22	2.36	2.03	5.85	6.4	4.75	12	
Artocarpus rigida...	30	Perian	15	19	21	17	3,950	4,550	3,000	1.10	1.20	1.03	3.1	3.55	2.34	11	(*d*), (*e*)
Koompassia parvifolia	31	Tualang	17.5	41	46.5	38	6,200	8,000	3,050	2.22	2.43	1.99	5.4	7.1	2.65	9	(*b*), (*d*)
Melanorrhoea ? sp.	32	Rengas	45	43.5	44.5	42	6,400	7,400	4,850	2.10	2.20	2.02	6.1	7.1	4.6	9	(*r*)
Rhizophora conjugata	33	Bakau Minyak ...	20	58.5	61.5	57	10,000	10,700	9,850	3.40	3.60	3.18	9.03	9.25	8.85	5	(*m*), (*p*)
Dryobalanops aromatica	34	Kapur	19	46	48	44	7,600	8,500	6,900	2.56	2.80	2.35	6.9	7.5	6.1	12	
Dipterocarpus sp.	35	Keruing	17	41.5	45.5	36	6,100	7,750	5,050	1.76	2.20	1.35	4.7	5.9	3.85	12	(*c*)
Scorodocarpus borneensis	36	Kulim	16	46	48	44.5	6,500	7,850	4,650	1.9	2.34	1.57	5.34	6.5	3.95	12	(*b*), (*d*)
	37A	Kungkor (?) (air dry)	19	37.5	39.5	35.5	6,900	9,050	4,200	1.6	1.77	1.43	5.0	6.05	2.0	6	(*b*), (*j*)
	37B	„ (wet) ...	54				5,850	6,500	5,000	1.52	1.64	1.44	4.5	5.55	3.5	6	
Parinarium sp. ...	38A	Muntelor (air dry)	17	45.5	48.5	39.5	7,900	8,550	6,750	2.32	2.90	1.91	6.82	8.05	6.3	10	(*k*), (*p*)
„ ...	38B	„ (wet) ...	32				5,800	6,350	5,150	2.16	2.49	2.00	5.80	6.55	5.4	5	
Hopea sp.	39A	Merawan (air dry)	16	36.5	38.5	35	7,840	8,600	7,400	2.12	2.25	2.00	6.5	7.3	6.2	5	(*p*)
„	39B	„ (wet) ...	25				6,720	7,300	5,850	1.95	2.03	1.90	5.2	5.7	3.7	4	
Artocarpus sp. ...	40A	Keladang (air dry)	14	37.5	39	35.5	9,100	11,300	7,300	2.35	2.39	2.30	7.2	7.85	6.5	6	(*p*)
„ ...	40B	„ (wet) ...	61				8,000	8,900	6,850	2.25	2.33	2.17	6.52	7.15	5.55	6	
Mesua ferrea ...	41	Penaga	16	56	58	53.5	12,000	12,600	8,150	2.88	2.92	2.81	10.2	11.1	9.4	4	(*p*)
Shorea sp. ...	42A	Merani Kait Kait (dry)	23	32	35.5	30.5	6,050	6,850	5,250	2.06	2.20	1.91	4.88	5.5	4.35	6	
„	42B	„ (wet)	40				5,630	7,150	4,600	1.97	2.30	1.79	4.67	5.3	4.2	8	
Castanopsis sp. ...	43A	Berangan (dry) ...	17	35.5	39	33	5,800	6,250	5,300	1.51	1.60	1.32	4.4	5.45	3.5	6	
„ ...	43B	„ (wet) ...	27				5,200	5,800	4,300	1.54	1.64	1.41	4.42	5.0	3.7	8	
Dyera costulata ...	44A	Jelutong (wet) ...	20	23	23.5	22	3,400	3,750	3,150	1.00	1.06	.95	2.51	2.65	2.35	6	
„ ...	44B	„ (air dry)...	14				4,000	4,850	3,550	1.04	1.11	1.01	3.06	3.15	2.95	6	
Cassia siamea ...	45	Johor	18	53	56.5	49.5	8,870	11,300	7,350	1.98	2.26	1.72	6.88	8.2	4.95	10	(*d*), (*e*), (*r*)
?	46	Petaling Gajah ...	23	53	54.5	51	10,400	11,900	9,200	2.76	2.92	2.58	9.5	10.0	9.3	4	(*p*), (*s*)
Ixonanthes icosandra	47	Pagar Anak ...	16	43.5	43.5	43	8,200	8,900	7,900	2.38	2.46	2.28	7.4	8.0	6.2	3	(*p*)

Botanical name.	Material batch number.	Name of timber.	Per cent. moisture at time of test.	Dry weight in lbs. per cubic foot.			Elastic limit in lbs. per square inch.			Modulus of elasticity in 106 lbs. per square inch.			Modulus of rupture in tons per square inch.			Number of specimens in batch.	Remarks. *See* page 9.
				Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.	Average.	Maximum.	Minimum.		
1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
Eugenia Ridleyi ...	48	Kelat	16	43	43.5	42.5	8,020	8,450	7,600	2.81	2.86	2.76	7.35	7.45	7.25	2	(*g*)
Shorea sp. ...	49	Seraya Batu ...	16	48.5	...	...	7,350	...	...	1.66	...	...	5.85	...	...	1	
?	50	Petaling Gajah ...	17	53.8	57.2	49.2	9,350	10,800	8,500	2.70	2.90	2.52	8.7	8.95	8.3	11	(*p*), (*s*)
Intsia sp.	51A	Merbau (dry) ...	16	44.8	46.9	40.9	9,830	12,400	8,500	2.26	2.32	2.09	7.35	7.75	6.75	6	(*p*)
,, ..., ...	51B	,, (wet) ...	26				9,700	10,400	8,950	2.37	2.51	2.23	7.26	7.45	6.95	9	
Sloetia sideroxylon	52	Tempinis ...	16	53.0	54.0	51.7	12,450	14,900	11,300	2.90	3.18	2.72	10.25	10.9	9.85	5	(*g*)
Balanocarpus penangianus ...	53	Damar Hitam ...	25	34.2	35.9	31.2	5,770	6,300	4,950	1.83	1.88	1.71	5.1	5.4	4.7	8	
Shorea sp. ...	54	Damar Laut Daun Kechil	17	58.5	60.7	56.5	9,750	11,500	7,300	2.86	2.32	2.54	8.15	9.4	6.65	13	(*g*), (*p*)
,, ...	55	Damar Laut Daun Besar	18	52.8	55.3	49.7	7,800	9,100	6,100	2.68	2.87	2.52	8.00	9.65	6.8	11	(*p*)
Hopea sp. ...	56A	Jangkang (Merawan dry)	18	44.8	48.2	43.5	8,000	10,200	6,100	2.48	2.66	2.30	7.1	7.9	6.65	5	(*b*)
,, ...	56B	,, (wet)	23				10,050	10,600	9,100	2.60	2.80	2.50	7.85	8.25	6.96	5	
	57	Meranti Sutri or Bakau	18	31.7	35.3	29.8	4,750	5,400	3,600	1.47	1.60	1.32	4.05	4.3	3.7	9	
Shorea Macroptera	58	Melantai	21	28.3	30.8	24.5	5,650	7,000	4,100	1.77	1.97	1.55	4.3	4.9	3.75	11/12	(*b*), (*s*)
,, leprosula ...	59	Meranti Bunga ...	18	30.1	32.3	28.7	5,450	5,950	4,950	1.71	1.79	1.56	4.35	4.6	3.85	8/9	
,, parvifolia...	60	Meranti Sarang Punai	19	27.2	32.8	23.8	4,700	5,500	3,800	1.47	1.58	1.34	3.7	4.25	2.9	12	(*n*)
,, Acriminta	61	Meranti Rambai Daun	20	27.9	30.0	24.8	4,800	5,700	4,250	1.43	1.58	1.33	4.2	4.65	3.65	14	(*s*)
,, Sericea ...	62	Meranti Kepong...	17	23.3	26.3	20.3	4,050	4,350	...	1.43	1.57	...	3.35	3.85	...	9/12	(*b*), (*d*), (*j*)
	63	Manupai	14	64.5	67.8	60.7	11,100	11,800	10,600	3.10	3.35	2.87	10.7	11.1	10.3	4	(*g*), (*p*)
	64	Malut	12	54.6	57.0	49.0	9,150	12,200	7,150	2.57	2.94	1.88	8.10	9.5	6.55	5	(*b*), (*g*)
	65	Rasak (Kedah name)	14	52.2	53.3	51.2	9,300	9,600	9,050	3.19	3.28	3.10	9.35	9.8	8.9	2	

	66	Kungkor	16	35.5	41.7	28.6	7,200	9,400	6,050	1.80	2.16	1.55	5.2	7.5	3.7	15	(*d*)
Balanocarpus Penangianus ...	67	Damar Hitam ...	23	39.3	41.2	37.6	6,400	7,100	5,050	1.56	1.76	1.40	4.75	5.55	3.75	12	
Shorea sp. ...	68	Damar Laut Daun Besar	16	51.7	53.7	49.3	9,300	10,600	7,900	2.78	3.23	2.29	8.90	10.1	7.15	10	(*p*)
,, ...	69	Damar Laut Daun Kechil	17	56.3	60.0	53.4	8,250	9,300	7,450	2.43	2.66	2.12	8.2	8.8	7.15	12	(*p*)
Diospyros sp. ...	70	Kayu Arang ...	16	49.8	51.9	47.5	7,650	9,150	6,400	2.27	2.58	1.94	7.00	8.15	5.25	8	(*e*)
Sindora sp. ...	71	Sepetir	16-17	31.7	33.0	30.0	5,550	6,800	4,150	1.50	1.70	1.22	4.3	4.95	3.4	13	(*b*), (*e*)
Palaquium sp. ...	72	Mai-aug	15	38.2	40.3	36.1	4,700	5,200	3,300	2.40	2.60	2.07	6.05	6.85	5.35	12	(*j*)
Campnosperma sp.	73	Terentang ...	16	21.7	24.4	18.8	3,200	3,750	2,050	1.12	1.37	.96	2.65	3.4	1.45	13	(*d*), (*e*), (*j*)
Bassia sp. ...	74	Belian	19	56.4	57.5	55.8	8,100	9,200	7,500	2.53	2.65	2.44	8.25	8.8	7.9	3	(*p*)
Eusideroxylon wageri	75	Billian	13-14	58.5	59.0	57.3	13,350	14,000	12,700	3.41	3.52	3.30	11.0	11.5	10.8	4	(*p*)
Sloetia sideroxylon	76	Tempinis	12	53.6	55.5	52.6	13,650	14,400	12,600	2.81	3.00	2.72	11.60	11.9	11.3	6	(*p*), (*s*)

(*a*) Probably a reliable timber if specimens free from knots are obtained.
(*b*) Note variability of elastic limit.
(*c*) ,, ,, modulus of elasticity.
(*d*) ,, ,, modulus of rupture.
(*e*) Timber found to be brittle.
(*f*) Timber liable to get mouldy if dried by ordinary methods.
(*g*) Condition of specimens poor.
(*h*) Timber apparently would offer great resistance to shear.
(*j*) Probably a useless timber for structural work.
(*k*) This timber is apparently strong in direct tension but weak in shear along the grain.
(*m*) Apparently a very strong timber in true tension.
(*n*) A doubtful timber which might be improved by kiln-drying.
(*p*) This timber should prove of general utility, and could probably be relied upon.
(*r*) Probably good for furniture.
(*s*) A timber which should be useful where flexibility is desired.